PERFORMANCE OF RECYCLED POLYMERIC FIBER AS REINFORCEMENT IN BITUMINOUS MIXTURE FOR ROAD MAINTENANCE WORKS

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DEDICATION

For my mother, father, wife and children

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ABSTRACT

Road maintenance is an integral part of creating a good and safe road network. The quality of patching mixture is also seen as an important aspect. Existing bituminous mixture used for road maintenance tends to deteriorate after patching work is completed. This might be due to the differences in stiffness when compared to existing aged pavement. In this research, fibers made from recycled polyethylene terephthalate (PET) are used as reinforcement to increase bituminous mix stiffness and enhance the strength of road maintenance mixture. Three fiber sizes were used at different percentages namely: RPET FA (0.78 x 10mm), RPET FB (3 x 20mm) and RPET FC (3 x 10mm). Water absorption, tensile strength, specific gravity and dynamic mechanical properties tests were conducted on the fiber and found to be suitable for mixture improvements. These fibers are mixed with bituminous mixes for testing. The results showed an improvement of moisture susceptibility of RPET FC by 8%, RPET FB by 6% and RPET FA mixture by 5% compared to control mixture. For fatigue, RPET FC mixture has improved by 120% whereas for rutting resistance of RPET FC mixture has improved by 32% compared to control mixture. A field test was also conducted in this research. After 500 vehicular passes at service temperature (45^{o}C), deformation resistance in the reinforced test pit has improved by 29%. It was found that a significant relationship between fiber properties and performance of recycled PET fiber reinforced mixtures were found. A small sized fiber seems to have less reinforcing ability while a big size fiber does not mean it will have a better ability to act as a reinforcement material. In this research, RPET FC was found to be the best sized fiber at 3mm x 10mm. Based on the findings of this research, RPET FC mixture at 0.3% and RPET FA mixture at 0.5% can be used for road maintenance. It is expected that this research will contribute towards better road maintenance works and reduce road surface defects in the future.

ABSTRAK

Penyelenggaraan jalan raya adalah sebahagian dari usaha mewujudkan jaringan jalan raya yang baik dan selamat. Kualiti campuran bahan tampalan juga dilihat sebagai satu aspek yang penting. Bahan berbitumen sediada yang digunakan untuk penyelenggaraan jalan raya mengalami kerosakan setelah selesai kerja penampalan. Ini mungkin disebabkan oleh perbezaan kekerasan bahan baharu dan sediada. Dalam kajian ini serat dari bahan plastik dikitar semula (PET) telah digunakan bagi memperkuatkan campuran bahan berbitumen untuk meningkatkan kekerasan dan kekuatan bahan. Tiga saiz serat dari bahan plastik dikitar semula dengan peratusan yang berbeza telah digunakan iaitu RPET FA (0.78 x 10mm), RPET FB (3 x 20mm) and RPET FC (3 x 10mm). Ujian penyerapan air, kekuatan tensil, ujian graviti tentu dan ujian ciri-ciri dinamik mekanikal terhadap serat telah dijalankan dan mendapati ia adalah sesuai untuk penambahbaikan bahan berbitumen. Seterusnya, bahan serat ini dimasukkan dalam bahan berbitumen untuk diuji. Keputusan ujian menunjukkan penambahbaikan terhadap kecenderungan kelembapan untuk campuran RPET FC sebanyak 8%, RPET FB 6% dan RPET FA sebanyak 5% berbanding dengan campuran kawalan. Bagi ujian kelesuan bahan, campuran RPET FC menunjukkan peningkatan sebanyak 120% manakala bagi ujian rintangan aluran bagi RPET FC menunjukkan penambahbaikan sebanyak 32% jika dibandingkan dengan campuran kawalan. Ujian di lapangan juga dilaksanakan dalam kajian ini. Setelah 500 kali laluan kenderaan di atas bahan tampalan yang disediakan di tapak pada suhu servis (45^{o}C), kerosakan yang berlaku terhadap bahan tampalan yang diubahsuai adalah 29% lebih baik dari bahan kawalan. Kajian mendapati iaitu hubungan yang signifikan telah diperhatikan. Saiz serat yang kecil didapati mampu memberikan daya menguatkan campuran bahan berbitumen yang rendah manakala saiz serat yang besar tidak bermakna ia mempunyai kekuatan yang lebih baik berbanding dengan saiz yang kecil. Kajian ini mendapati saiz RPET FC adalah saiz yang terbaik pada

saiz 3mm x 10mm. Berdasarkan hasil kajian ini, campuran RPET FC pada 0.3% dan RPET FA pada 0.5% boleh digunakan bagi penyenggaraan jalan raya. Kajian ini dijangka akan dapat menyumbang kepada kerja-kerja penyelenggaraan jalan raya yang lebih baik dan mengurangkan kerosakan permukaan jalan raya pada masa hadapan.

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LIST OF ABBREVIATIONS

AASTHO	American Association of State Highway and Transportation Officials
ANOVA	One-way Analysis of Variance
ASTM	American Society for Testing Materials
AV	Air Void
BS	British Standard
DMA	Dynamic Mechanical Analysis
DP	Dust Proportion
E’	Storage Modulus
E”	Loss Modulus
EV	Elevation reading
FHWA	Federal Highway Administration
Gmb	Specific Gravity of Compacted Mixture
Gmm	Maximum Specific Gravity
HMA	Hot Mix Asphalt
HP	Height of prism pole
HT	Height of total station
IDT	Indirect Tensile
ITS	Indirect Tensile Strength
LVDT	Linear Variable Displacement Transducers
MR	Resilient Modulus
NCAT	National Center for Asphalt Technology
OBC	Optimum Bitumen Content
PET	Polyethylene Terephthalate
PG	Performance Grading
R^2	Coefficient of Determination
RAP	Reclaimed Asphalt Pavement

RPET FA	Recycled Polyethylene Terephthalate Fiber type A
RPET FB	Recycled Polyethylene Terephthalate Fiber type B
RPET FC	Recycled Polyethylene Terephthalate Fiber type C
RSM	Response Surface Methodology
RV	Rotational Viscometer
SGC	SUPERPAVE Gyratory Compactor
SHRP	Strategic Highway Research Program
SUPERPAVE	Superior performing asphalt pavement
Tan δ	Tan Delta
TSR	Tensile Strength Ratio
UTM	Universal Testing Machine
VD	Vertical distance
VFA	Void Filled with Asphalt
VMA	Void in Mineral Aggregate
VTM	Void in Total Mixture
WMA	Warm Mix Asphalt

CHAPTER 1

INTRODUCTION

1.1 Background

The quality of roads constructed is important for economic and social development of any society. Poorly maintained roads restrict mobility, increase operating costs, increase accident rates, and aggravate isolation, poverty, poor health, and illiteracy in rural communities. Road improvements and maintenance ensures a smooth and safe access to schools, hospitals and markets that can only be achieved through a well planned maintenance strategy using qualitative materials (Burningham & Stankevich, 2005).

Road maintenance involve activities to keep the pavement, shoulders, slopes, drainage facilities and all other structures and properties within the road margins as near as possible to their as-constructed or renewed condition. Bituminous pavement is designed to serve for a specific period of time but it often result in early deterioration due to construction quality, traffic volume, axle load characteristics, which depend upon all the nature of materials used and maintenance policy (Gedafa, 2007). Most highway pavements have bituminous surface, which are designed not only to carry and distribute wheel loadings but also to provide an impermeable covering to all lower pavement layers. Bituminous pavement contains bitumen binder and aggregates as the two principal constituents (Earnest, 2015) laid for transportation of people and goods across the world.

However, due to weathering, increased traffic load and sustained use, bituminous pavements suffer deterioration and often require maintenance throughout their typical 26-30 years of designed service life. Rutting and cracking are key failure

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